Resonant scattering of polarized soft x-rays for the study of magnetic oxide layers

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Magnetic oxides, particularly in the form of thin films, are the object of intense study in both fundamental and applied research[1]. The epitaxial growth of magnetic iron oxides on oxides allows to obtain high quality single crystal thin films that serve as a reference for the investigation of the fundamental characteristics of these systems in terms of electronic and magnetic properties, covering the thickness range from the monolayer to the bulk[2]. Spectroscopic techniques which are appropriate for these investigations are often based on electron detection (e.g. LEED, XPS, spin analysis and even absorption performed in electron yield mode on thick samples), hence affected by the insulating nature of both sample and substrate. As a complement to electron based spectroscopies, we have applied resonant scattering of polarized soft x-rays[3] (a photon-in / photon-out technique) to the study of epitaxial oxide layers. Experiments were performed on the reflectometer of beamline 6.3.2 at ALS, using linearly and elliptically polarized light. Test samples were epitaxial Fe_2O_3 and Fe_3O_4 layers grown on sapphire.

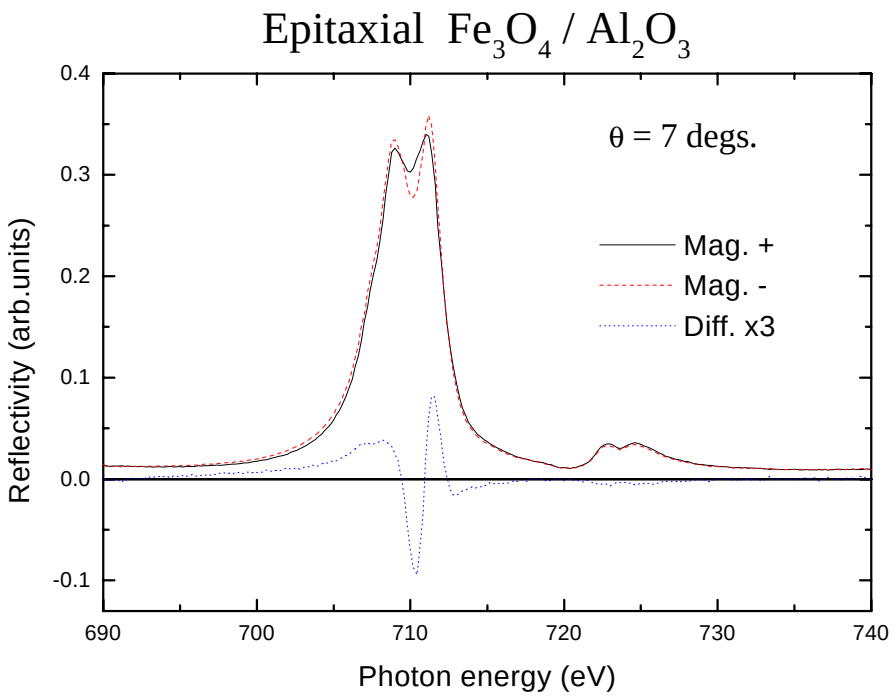

Fig. 1. Resonant magnetic scattering of elliptically polarised x-rays at the Fe 2p edges in an epitaxial iron oxide film. The two curves refer to opposite magnetization/helicity orientations.

The experimental geometry allowed to search for both linear dichroism related to antiferromagnetic ordering in Fe_2O_3 and circular dichroism coming from the ferrimagnetic ordering in Fe_3O_4 (see Fig. 1). Elastic x-ray scattering can be used at the same time for a structural analysis on the layers, studying the angular dependence of the reflectivity (Fig. 2).

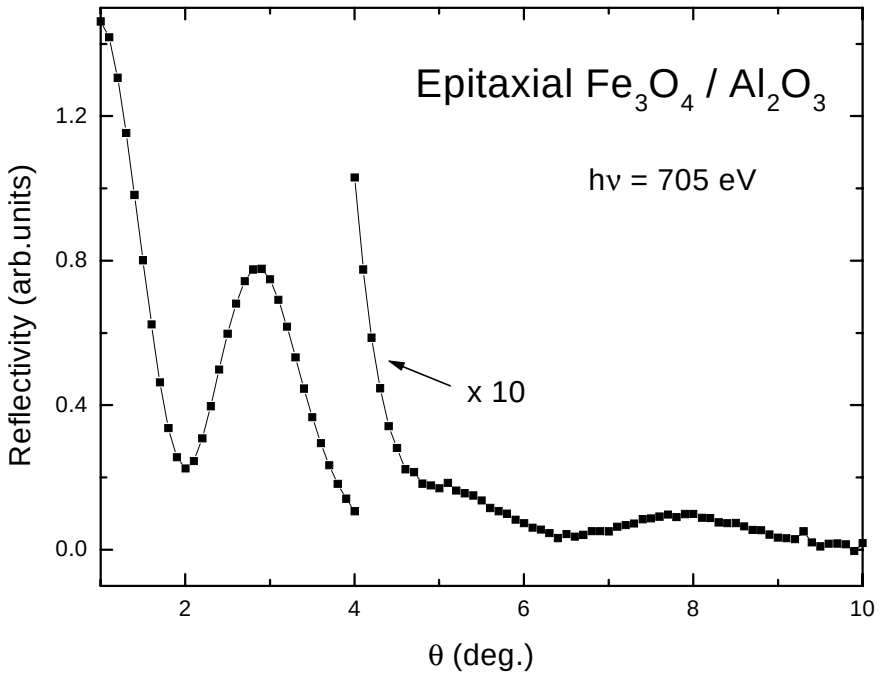

Fig. 2. Reflectivity versus scattering angle at 705 eV. Three structures can be identified, related to the thickness of the iron oxide layer.

We have then a technique that can give spectroscopic as well as microstructural information with very high sensitivity, capable of working on insulating samples and in presence of high magnetic fields. Moreover, the well defined relation between resonant scattering and absorption allows a natural extension to the former of dichroism sum rules for an element selective and quantitative evaluation of the magnetic moments.

REFERENCES

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This work was supported by the Centre National de la Recherche Scientifique and by the Commisariat à l'Energie Atomique (France)

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